



Influence of Soil Application through Integrated Nutrient Management on Soil Characteristics of Sweet Orange Orchard in Gird Region of Madhya Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out from November 2020 to March 2022 at the RVSKVV College of Agriculture's Research Farm, located in Gwalior (M.P.), in the Department of Horticulture. Three replications and a Randomized Block Design were used to set up the experiment. The all soil

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characteristics analysis both initial and final level after experiment respectively minimum soil pH (7.05, 7.49), EC dsm^{-1} (0.225, 0.220) and maximum Organic carbon % (2.117, 3.263), Nitrogen Kg ha^{-1} (177.14,187.29), Phosphorus Kg ha^{-1} (13.38, 13.58) and Potassium Kg ha^{-1} (207.88, 229.45) quality parameters were most effectively achieved with treatment T₅ RDF 90 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron). Because sweet orange orchards are located in the Gird Region of Madhya Pradesh, this particular treatment is most suited for use there.

Keywords: Sweet orange; bio fertilizer; vermicompost; nitrogen; phosphorus; potassium.

1. INTRODUCTION

Sweet orange (*Citrus Sinensis* L.) is an important fruit crop which belongs to family Rutaceae, especially citrus fruit which are generally known to be rich in these vitamins and minerals. Sweet oranges need a well-drained medium or soft loam soil with a 2-3 cm depth of slightly heavier subsoil. Cultivation generally avoided in shallow soils. It grows in a wide variety of soil types, from clay to light sandy, and is salt tolerant. Mineral elements are acquired by plant roots from soil solution under optimum soil moisture and temperature. The nutrient availability and uptake is influenced by soil physical, chemical, mineralogical and biological properties. The important soil properties that affect the nutrient availability include soil depth, soil PH, BC, CaCO₃ content, organic carbon content and plant nutrients concentration in soil solution. Sometimes soil possesses sufficient amount of nutrient concentration in soil media but its availability become to plant is hindered due to some external factors, under such situation foliar feeding of nutrient become necessary to save the crop. yield and quality of produce.

The integrated nutrient management infuses long term sustainability in the productivity level because of availability of nutrients in soil for next season crop. Incorporation of organic fertilizers is a common practice to improve the yield of many fruit crops. It also limits chemical intervention and finally minimizes the negative impact on the wider environment. it is the important alternative source, which is not only beneficial to maintain the soil health but also to sustain the fruit production. Application of organic manure combined with chemical fertilizer is associated with increased soil fertility and improved soil physical and chemical properties, thus it can increase crop production.

2. MATERIALS AND METHODS

2.1 Site of Experiment

In the academic year of 2021–22, the experiment was carried out in the Research Farm of the Department of Horticulture at RVSKVV College of Agriculture, Gwalior (Madhya Pradesh. The Gwalior is situated at 26° 13' N latitude and 78° 14' E longitudes at an altitude of 211.5 m above mean sea level (MLS) in Gird region. It has a subtropical climate with hot and summer where maximum temperature exceeds 45°C in May June. The winters are cold and are minimum temperature reaches as low as 2°C in December and January. Frost generally occurs from the last week of December to first week of February. Usually the monsoon arrives in the second fortnight of June and lasts mid of September.

The experiment was laid out in completely randomized design considering the uniformity of 10-year-old cv. Mosambi plants (6 x 6 m) with thirteen treatments and replicated thrice during the two years (2021 and 2022) of research.

2.1.1 Methods of application of treatments

For application of manure and fertilizers the top soil around the tree (equal to the leaf canopy of the tree) is dug up to 30 cm and the fertilizers were uniformly mixed into the soil and thereafter, it was levelled. Irrigation was supplied immediately after fertilizer application.

- Recommended dose: 800 g N₂/plant, 400 g P₂O₅/plant, 400 g K/plant
- Urea, di ammonium phosphate and murate of potash were used as the source of nitrogen, phosphorus and potassium. The dose of NPK was given as per treatment.
- Vermicompost, PSB, KMB and Azotobacter were also applied as per treatment.
- Zn, Cu, Iron and Boron were also applied as a micro nutrient.

Table 1. Describes the different treatments

Treatments symbol	Treatments details
T ₁	RDF (Recommended Dose of Fertilizer) 100 % (800:400:400 g/plant) Control
T ₂	RDF 90 % + Vermicompost
T ₃	RDF 90 % + Vermicompost + (Azotobacter + PSB + KMB)
T ₄	RDF 90 % + Vermicompost + (Zn + Cu + Fe + Boron)
T ₅	RDF 90 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron)
T ₆	RDF 80 % + Vermicompost
T ₇	RDF 80 % + Vermicompost + (Azotobacter + PSB + KMB)
T ₈	RDF 80 % + Vermicompost + (Zn + Cu + Fe + Boron)
T ₉	RDF 80 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron)
T ₁₀	RDF 70 % + Vermicompost
T ₁₁	RDF 70 % + Vermicompost + (Azotobacter + PSB + KMB)
T ₁₂	RDF 70 % + Vermicompost + (Zn + Cu + Fe + Boron)
T ₁₃	RDF 70 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron)

3. RESULTS AND DISCUSSION

The results (Tables 2,3 and 4) showed the initial and final soil analysis levels for various applications of integrated nutrient management in sweet orange orchards.

3.1 Soil pH

The minimum soil pH at initial and final level (6.80,7.62, 7.05 and 7.64, 7.64, 7.55 during first, second and pooled year respectively) was recorded under the treatment T₅ (RDF 90 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) which was significantly superior to all the treatments under study. Treatment T₅ was followed by T₉ (RDF 80 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) that reported soil pH at initial and final level of 7.55,7.25, 7.50 and 7.62, 7.62, 7.62 during first, second and pooled year respectively. The maximum soil pH at initial and final level (7.74, 7.85, 7.68 and 7.85, 7.87, 7.86 during first, second and pooled year respectively) was recorded under T₁₀ (RDF 70 % (560:280:280 g/plant/hectare) + Vermicompost). Naik and Babu [1] reported that there was increase in soil pH due to the application of different organic amended plots. This could be due to low buffering action of organic fertilizers and soil [2].

3.2 Soil Electrical Conductivity (dsm⁻¹)

The minimum electrical conductivity (dsm⁻¹) at initial and final level (0.265, 0.175, 0.225 and 0.265, 0.175, 0.220 during first, second and pooled year respectively) was recorded under the treatment T₅ (RDF 90 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) which was significantly superior to all the treatments under study. Treatment T₅ was followed by T₉ (RDF 80 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) that reported electrical conductivity (dsm⁻¹) at initial and final level of 0.267, 0.253 and 0.260 and 0.267, 0.253, 0.260 during first, second and pooled year respectively. The maximum electrical conductivity (dsm⁻¹) at initial and final level (0.378, 0.362, 0.370 and 0.378, 0.362, 0.370 during first, second and pooled year respectively) was recorded under T₁₀ (RDF 70 % (560:280:280 g/plant/hectare) + Vermicompost). The increase in total salt from added organic manures was probably high which in turn affected EC of the soil Beri et al. [3].

3.3 Organic Carbon %

The maximum organic carbon % at initial and final level (2.117, 2.257, 2.278 and 2.994, 3.532, 3.263 during first, second and pooled year respectively) was recorded under the treatment T₅ (RDF 90 % + Vermicompost +

Table 2. Influence of soil applications through Integrated Nutrient Management on Soil pH and electrical conductivity in Sweet Orange Orchard cv. Mosambi (*Citrus Sinensis* L.)

Treatments symbol	Soil pH Initial level			Soil pH Final Level			Electrical conductivity initial level dsm^{-1}			Electrical conductivity final level dsm^{-1}		
	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled
T ₁	7.47	7.68	7.41	7.65	7.73	7.71	0.321	0.272	0.297	0.321	0.272	0.297
T ₂	7.66	7.83	7.56	7.83	7.83	7.83	0.373	0.354	0.364	0.373	0.354	0.364
T ₃	7.46	7.47	7.40	7.63	7.62	7.63	0.273	0.263	0.268	0.273	0.263	0.268
T ₄	7.43	7.63	7.38	7.64	7.65	7.65	0.277	0.264	0.270	0.277	0.264	0.270
T ₅	6.80	7.62	7.05	7.64	7.64	7.55	0.265	0.175	0.225	0.265	0.175	0.220
T ₆	7.74	7.85	7.68	7.85	7.87	7.86	0.378	0.362	0.370	0.378	0.362	0.370
T ₇	7.67	7.27	7.62	7.73	7.73	7.73	0.353	0.274	0.314	0.353	0.274	0.314
T ₈	7.53	7.73	7.48	7.78	7.78	7.70	0.363	0.286	0.325	0.363	0.286	0.325
T ₉	7.55	7.25	7.50	7.62	7.62	7.62	0.267	0.253	0.260	0.267	0.253	0.260
T ₁₀	7.77	7.86	7.72	7.86	7.88	7.87	0.385	0.374	0.379	0.385	0.374	0.379
T ₁₁	7.60	7.61	7.53	7.83	7.83	7.58	0.354	0.284	0.319	0.354	0.284	0.319
T ₁₂	7.59	7.76	7.52	7.76	7.77	7.77	0.373	0.353	0.363	0.373	0.353	0.363
T ₁₃	7.47	7.64	7.41	7.74	7.73	7.49	0.284	0.266	0.275	0.284	0.266	0.275
SE(m)	0.12	0.06	0.09	0.01	0.01	0.01	0.009	0.001	0.005	0.003	0.008	0.005
CD (5%)	0.35	0.19	0.32	0.04	0.03	0.36	0.026	0.004	0.058	0.010	0.023	0.057

Table 3. Influence of soil applications through Integrated Nutrient Management on Soil organic carbon and nitrogen in Sweet Orange Orchard cv. Mosambi (*Citrus Sinensis* L.)

Treatments symbol	Organic Carbon % initial level			Organic Carbon % final level			Nitrogen initial level (Kg ha^{-1})			Nitrogen Final level (Kg ha^{-1})		
	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled
T ₁	1.367	1.335	1.351	2.758	2.767	2.763	163.52	184.00	173.76	174.29	193.81	184.05
T ₂	1.112	1.225	1.169	1.547	1.892	1.720	159.59	175.46	167.53	164.90	187.60	176.25
T ₃	2.112	2.151	2.131	2.834	3.036	2.935	167.27	185.74	176.51	175.59	197.49	186.54
T ₄	1.552	2.116	1.834	2.809	2.924	2.866	166.66	185.34	176.00	175.12	196.93	186.02
T ₅	2.117	2.257	2.187	2.994	3.532	3.263	167.76	186.52	177.14	176.34	198.24	187.29
T ₆	0.998	1.182	1.090	1.451	1.396	1.424	158.17	173.38	165.78	163.74	186.97	175.35
T ₇	1.224	1.332	1.278	2.700	2.708	2.704	163.26	183.18	173.22	173.76	192.71	183.23
T ₈	1.189	1.227	1.208	2.433	2.313	2.373	162.93	178.70	170.81	168.45	187.65	178.05
T ₉	2.117	2.254	2.185	2.851	3.322	3.086	167.49	185.87	176.68	175.62	197.50	186.56
T ₁₀	0.996	1.117	1.056	1.318	1.371	1.344	157.67	173.35	165.51	162.98	184.58	173.78
T ₁₁	1.220	1.324	1.272	2.447	2.447	2.447	163.17	180.38	171.78	173.34	191.70	182.52

Treatments symbol	Organic Carbon % initial level			Organic Carbon % final level			Nitrogen initial level (Kg ha ⁻¹)			Nitrogen Final level (Kg ha ⁻¹)		
	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled
T ₁₂	1.115	1.227	1.171	2.017	2.279	2.148	161.93	177.25	169.59	166.85	187.64	177.25
T ₁₃	1.415	1.342	1.378	2.775	2.792	2.784	163.68	185.06	174.37	174.62	196.16	185.39
SE(m)	0.010	0.023	0.016	0.277	0.175	0.226	1.15	0.99	1.07	1.23	0.90	1.06
CD (5%)	0.030	0.068	0.288	0.812	0.514	0.391	3.37	2.91	3.96	3.61	2.65	2.93

Table 4. Influence of soil applications through Integrated Nutrient Management on Soil phosphorus and potassium in Sweet Orange Orchard c.v. Mosambi (*Citrus Sinensis* L.

Treatments symbol	Phosphorus initial level (Kg ha ⁻¹)			Phosphorus Final level (Kg ha ⁻¹)			Potassium initial level (Kg ha ⁻¹)			Potassium Final level (Kg ha ⁻¹)		
	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled	Year 2021	Year 2022	Pooled
T ₁	11.78	12.27	12.03	12.36	12.87	12.62	184.37	223.60	203.98	202.27	237.83	220.05
T ₂	11.16	11.49	11.32	11.32	10.56	10.94	173.27	222.17	197.72	195.40	233.27	214.33
T ₃	11.90	13.26	12.58	12.87	13.74	13.31	187.30	224.97	206.13	208.07	243.73	225.90
T ₄	12.07	12.96	12.52	12.54	13.51	13.03	187.23	224.83	206.03	208.03	242.43	225.23
T ₅	13.22	13.54	13.38	12.96	14.19	13.58	188.63	227.13	207.88	213.67	245.23	229.45
T ₆	11.45	10.93	11.19	10.48	10.98	10.73	176.90	218.07	197.48	195.27	232.80	214.03
T ₇	11.42	11.99	11.71	12.28	12.04	12.16	184.23	222.53	203.38	199.13	237.67	218.40
T ₈	12.52	10.35	11.43	11.45	12.38	11.91	180.40	219.83	200.12	197.67	235.77	216.72
T ₉	12.97	13.40	13.19	12.81	14.14	13.47	187.67	226.80	207.23	213.13	244.90	229.02
T ₁₀	10.12	11.24	10.68	10.82	11.76	11.29	173.43	217.90	195.67	193.93	232.53	213.23
T ₁₁	10.79	12.45	11.62	11.70	12.47	12.08	183.40	220.53	201.97	198.53	236.90	217.72
T ₁₂	10.49	12.33	11.41	12.12	11.27	11.70	177.67	219.40	198.53	197.57	233.67	215.62
T ₁₃	12.25	12.69	12.47	12.82	13.12	12.97	186.10	223.93	205.02	203.77	239.50	221.63
SE(m)	0.521	0.543	0.532	0.45	0.55	0.50	0.90	1.40	1.15	1.13	0.94	1.03
CD (5%)	1.53	1.59	1.94	1.33	1.63	1.34	2.64	4.12	6.33	3.32	2.78	4.53

(Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) which was significantly superior to all the treatments under study. Treatment T₅ was followed by T₉ (RDF 80% + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) that reported organic carbon % at initial and final level of 2.117, 2.254, 2.185 and 2.851, 3.322, 3.086 during first, second and pooled year respectively. The minimum organic carbon % at initial and final level (0.996, 1.117, 1.056 and 1.318, 1.371, 1.344 during first, second and pooled year respectively) was recorded under T₁₀ (RDF 70% (560:280:280 g/plant/hectare) + Vermicompost). This might be due to the increase in soil micro flora which decomposes organic matter in soil resulting in to release of nitrogen in available form [4] in banana.

3.4 Nitrogen (kg ha⁻¹)

The maximum available nitrogen (kg ha⁻¹) at initial and final level (167.76, 186.52, 177.14 and 176.34, 198.24, 187.29 during first, second and pooled year respectively) was recorded under the treatment T₅ (RDF 90 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) which was significantly superior to all the treatments under study. Treatment T₅ was followed by T₉ (RDF 80 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) that reported available nitrogen (kg ha⁻¹) at initial and final level of 167.49, 185.87, 176.68 and 175.62, 197.50, 186.56 during first, second and pooled year respectively. The minimum available nitrogen (kg ha⁻¹) at initial and final level (157.67, 173.35, 165.51 and 162.98, 184.58, 173.78 during first, second and pooled year respectively) was recorded under T₁₀ (RDF 70% (560:280:280 g/plant/hectare) + Vermicompost). The use of microbial consortia in conjunction with organic manures and inorganic source of NPK proved efficient in maintaining soil nitrogen levels because the microbial population was substantially greater under such treatments. Mahendra et al. [5].

3.5 Phosphorus (kg ha⁻¹)

The maximum available phosphorus (kg ha⁻¹) at initial and final level (13.22, 13.54, 13.38 and 12.96, 14.19, 13.58 during first, second and pooled year respectively) was recorded under the treatment T₅ (RDF 90 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) which was significantly superior to all the treatments under study. Treatment T₅ was followed by T₉ (RDF 80% + Vermicompost +

(Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) reported available phosphorus (kg ha⁻¹) at initial and final level of 12.97, 13.40, 13.19 and 12.81, 14.14, 13.47 during first, second and pooled year respectively. The minimum available phosphorus (kg ha⁻¹) at initial and final level (10.12, 11.24, 10.68 and 10.48, 10.98, 10.73 during first, second and pooled year respectively) was recorded under T₁₀ (RDF 70 % (560:280:280 g/plant/hectare) + Vermicompost). Generally, addition of organic manures with inorganic fertilizers has been reported as beneficial in increasing the phosphorus availability [6].

3.6 Potassium (kg ha⁻¹)

The maximum available potassium (kg ha⁻¹) at initial and final level (188.63, 227.13, 207.88 and 213.67, 245.23, 229.45 during first, second and pooled year respectively) was recorded under the treatment T₅ (RDF 90% + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) which was significantly superior to all the treatments under study. Treatment T₅ was followed by T₉ (RDF 80 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) that reported available potassium (kg ha⁻¹) at initial and final level of 187.67, 226.80, 207.23 and 213.13, 244.90, 229.02 during first, second and pooled year respectively. The minimum available potassium (kg ha⁻¹) at initial and final level (173.27, 222.17, 197.72 and 193.93, 232.53, 213.23 during first, second and pooled year respectively) was recorded under T₁₀ (RDF 70% (560:280:280 g/plant/hectare) + Vermicompost). In spite of crop uptake more content of NPK was observed in soil. This may be attributed due to more activity and multiplication of nitrogen fixing bacteria and PSB in microbial consortia in the soil for further decomposition and mineralization of FYM, vermicompost and poultry manure might have contributed in availability of more nutrients in the soil Gogoi et al. [7], [8-12].

4. CONCLUSION

From the present study it may be concluded that:

The treatments had a significant effect on the nutritional status of orchard soil, viz. soil pH, soil electrical, conductivity, organic carbon%, available nitrogen, available phosphorus, available potassium were affected significantly by various treatments. Among the treatments, T₅ (RDF 90 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron) was found to be significantly superior to rest of the

treatments under study. It was however followed closely by T₉ (RDF 80 % + Vermicompost + (Azotobacter + PSB + KMB) + (Zn + Cu + Fe + Boron).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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